

Fermi

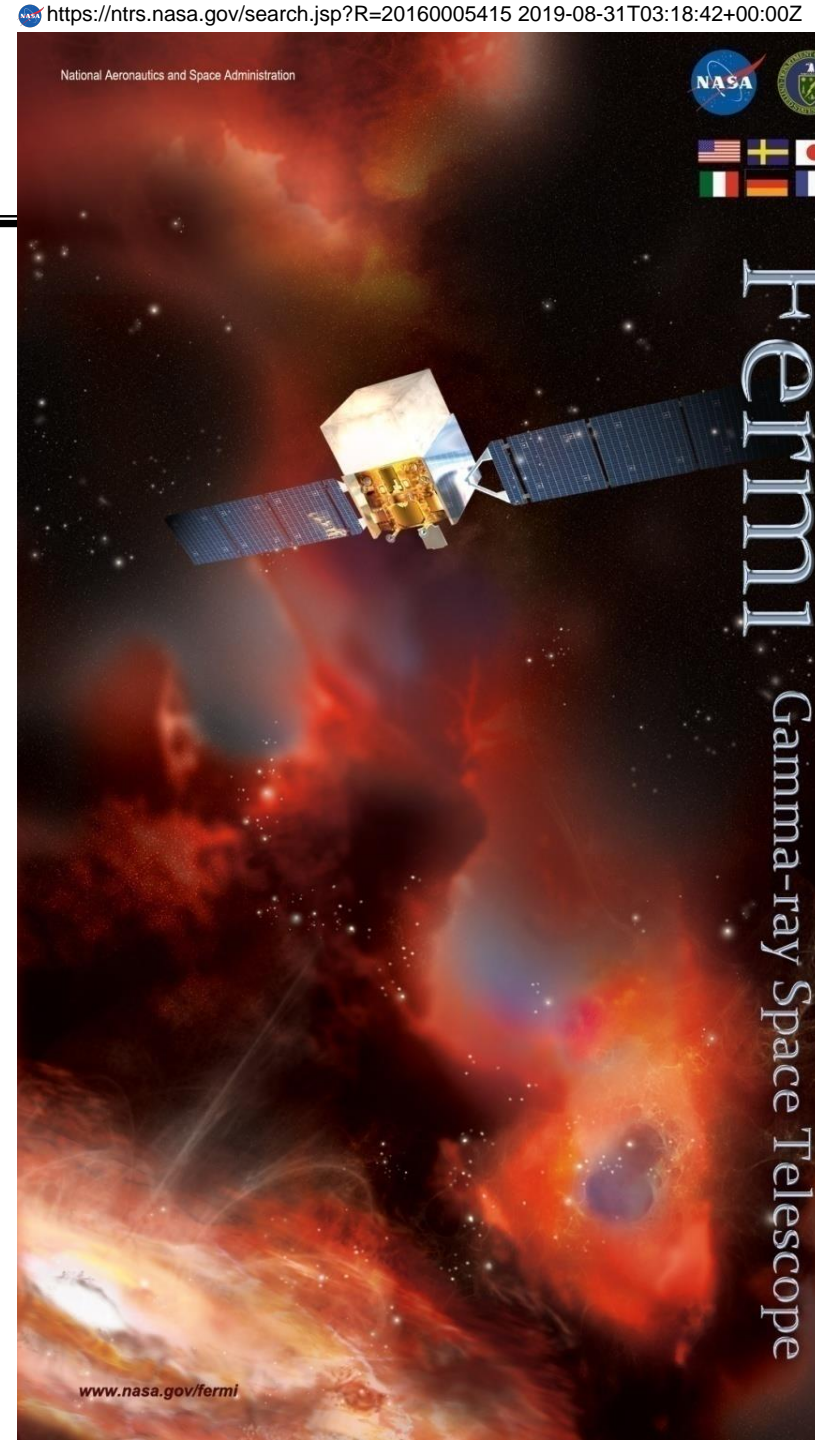
The Gamma-ray Large Area Space Telescope

Mission Status

Julie McEnery

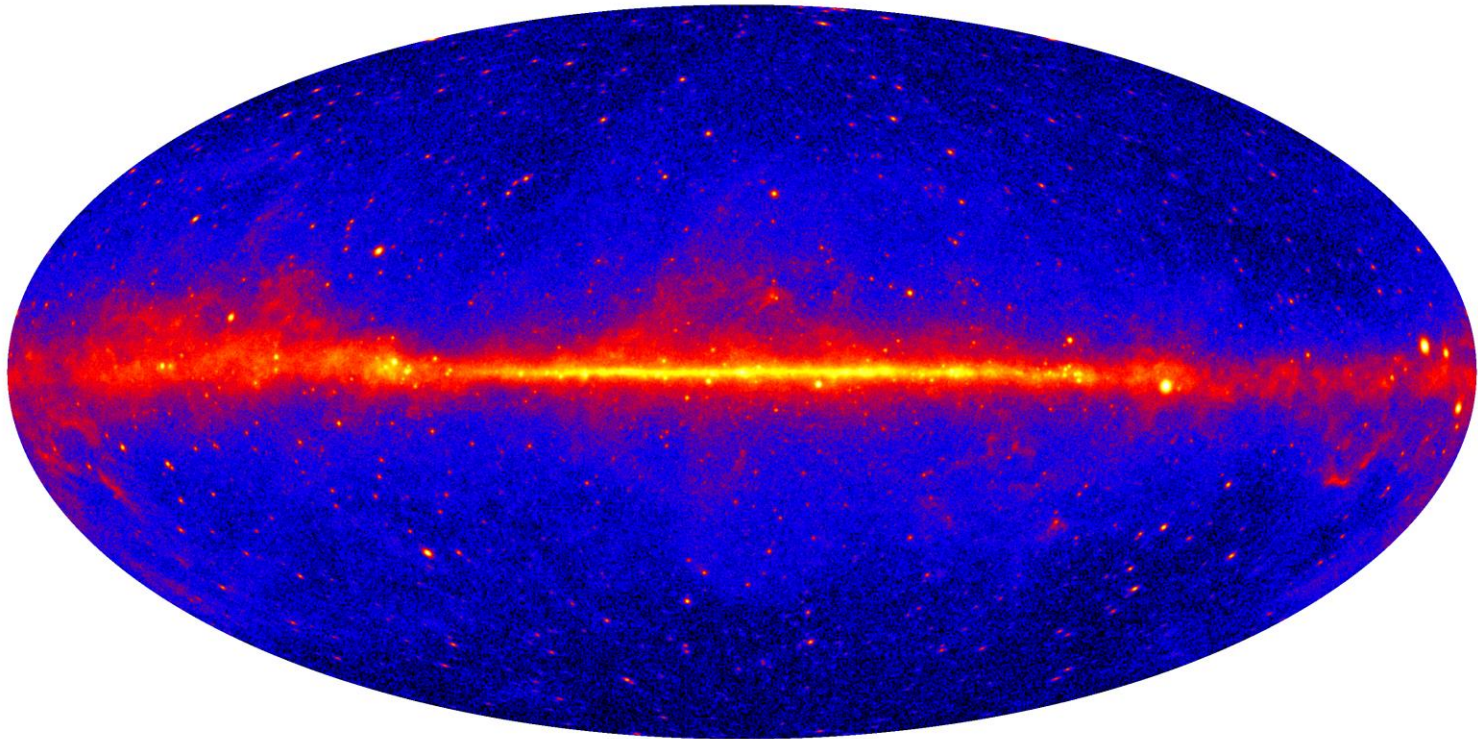
On behalf of the Fermi mission team

see <http://fermi.gsfc.nasa.gov> and
links therein

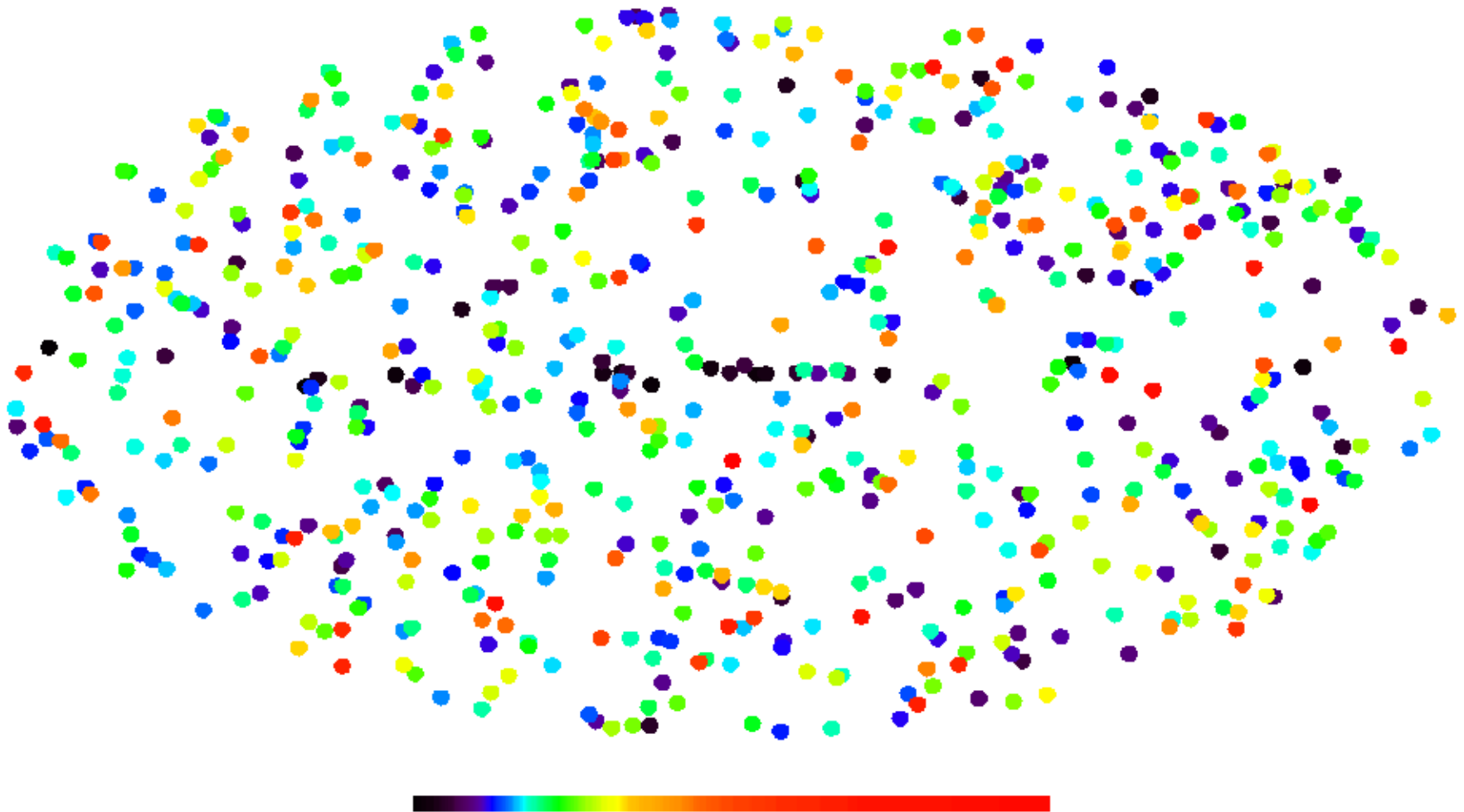


Fermi Status

- **Observatory is operating smoothly**
 - **instruments and spacecraft operate as designed, no degradation in science performance since launch**

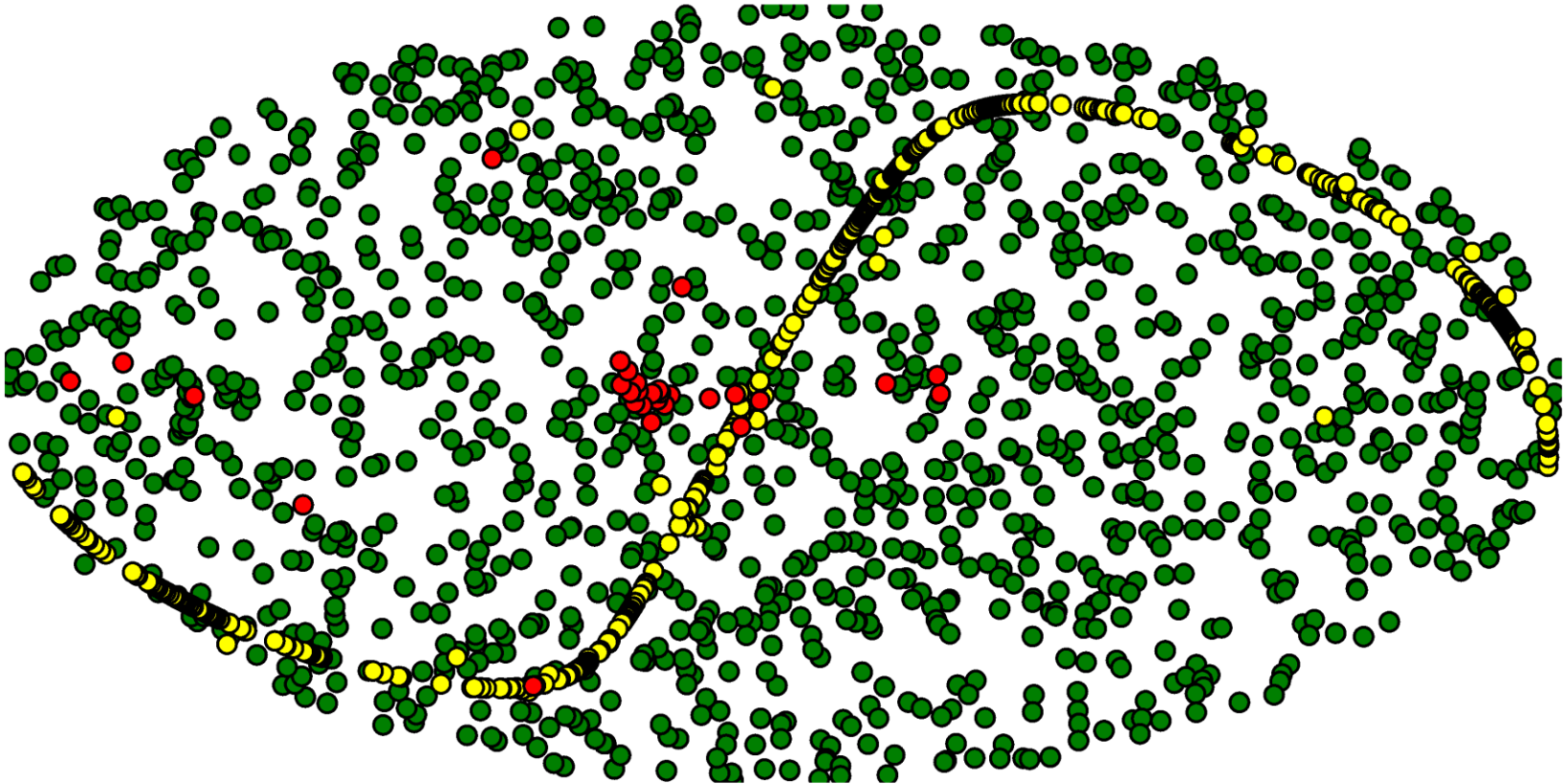


Fermi Status

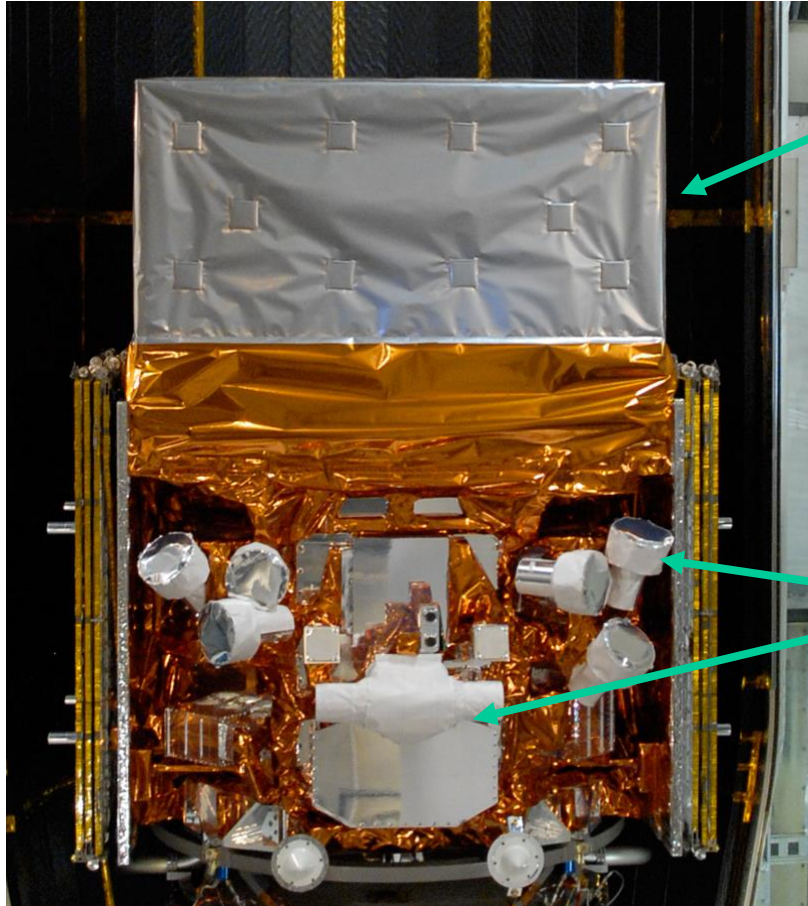


Fermi Status

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Fermi instruments



Large Area Telescope (LAT):

- 20 MeV - >300 GeV (including unexplored region 10-100 GeV)
- 2.4 sr FoV (scans entire sky every ~3hrs)

Gamma-ray Burst Monitor (GBM)

- 8 keV - 40 MeV
- views entire unocculted sky

- Large leap in all key capabilities, transforming our knowledge of the gamma-ray universe. Great discovery potential.

Gamma-ray Burst Monitor

- **Designed to complement high energy LAT GRB observations (GBM does much more than this!)**
 - **Provide rapid localization to allow autonomous repoint to bring GRB to center of LAT FoV**
 - **Detect all bright bursts in unocculted sky (i.e. anywhere not blocked by the Earth)**
 - **Extend sensitivity to high energies for spectral overlap with LAT**
 - **High energy sensitivity provides a boost for detection of short hard bursts relative to other current and previous GRB detectors**
 - **Recently transitioned to continuous Time Tagged Event data (TTE), preliminary tests indicate that this will increase the rate of short GRB to ~80/year (via a ground search)**
- **Summary:**
 - **GBM detects a large number of bright bursts, with a relatively rich fraction of short hard bursts.**

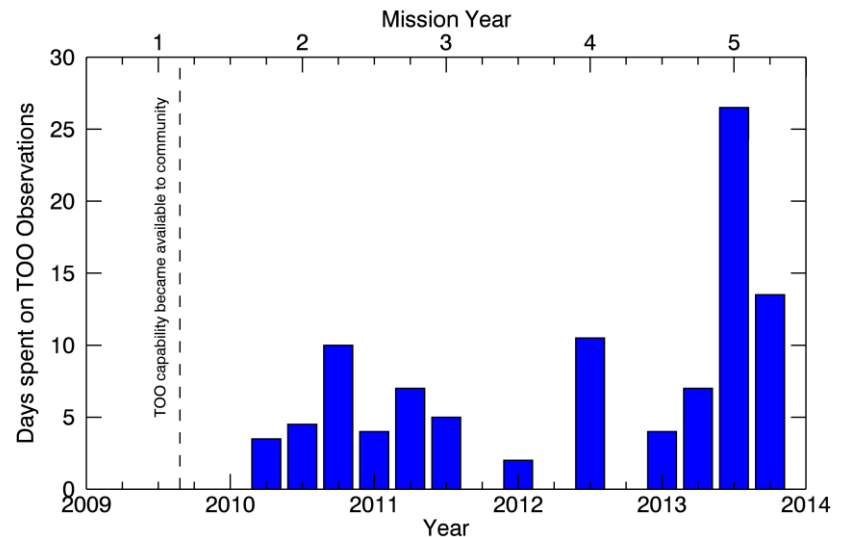
- **Currently serving P7REP data**
 - This has improved calorimeter calibrations relative to P7
 - Better angular resolution at high energies
 - Small shift in the energy scale
 - Updated galactic and isotropic diffuse models
- **Third point source catalog (3FGL)**
 - Based on 4 years of data and P7REP
 - Source list will be released within a few months
 - 3rd AGN catalog also in the works

Observatory Observations

- **In Galactic Center-Biased Sky Survey since early December**
 - Each orbit contains a mix of pointed mode and survey (fixed rocking angle).
 - Need to be careful with zenith and rocking angle selections.
- **Target of Opportunity requests are increasing**
 - Requests go straight to FSSC/Project

<http://fermi.gsfc.nasa.gov/ssc/observations/too/>

If you are planning to request a ToO, please submit the form early – we will work with you to evaluate the observation options.



Observatory cont.

- **Cycle 7 GI program**
 - 224 proposals
 - Review in late April
 - Funding starts in October
- **Senior Review Proposal**
 - Covers period 2015-2018
 - Proposed for mission extension and augmentation of GI program budget (so your success in the GI program may depend on our success in the senior review...)

How to work with us

- **Pick your favorite LAT or GBM team member and talk about what you would like to do**
 - **If you don't know who to contact send a note to Dave Thompson (david.j.thompson@nasa.gov) . He is the MW coordinator for LAT and GBM teams.**
 - **The LAT team member(s) will handle all interactions with the LAT science groups and publication board.**
 - **The intent of LAT team policies is to maintain our identity as a group that works and publishes together, and to maintain a consistently high standard for papers/analysis.**
- **An MOU can cover cases where you would like access to internal information to guide observations (e.g. high energy source list, or flaring source announcements) that are not necessarily tied to a specific analysis or papers**

LAT Papers

- For the LAT team, any paper that presents a new analysis of LAT data and has LAT authors is a LAT paper.
 - Cat 1 paper – major LAT result, authorship open to all LAT members, LAT author list block ordered alphabetically, 2 internal reviewers
 - Cat 2 paper – LAT authorship open only to those who directly participated in the paper, LAT author list block ordered at the discretion of the authors, 1 internal reviewer
 - Determination of whether a paper is cat 1 or 2 is by the science group leads (but they usually go with the recommendation of the authors)
 - LAT publication board approval needed before paper is submitted

Questions?

Science case for GC observation: Pulsars

- **Pulsar science is a major Fermi success story!**
 - **Many pulsars of many types discovered**
 - **Significant boost in our understanding of these objects**
- **Marked increase in sensitivity for pulsed searches near the Galactic center where the population of pulsars should be very large**
 - **Very high probability to detect new gamma-ray pulsars**
- **In the close vicinity of SgrA*, pulsation searches would have to account for accelerations due to orbital variability, orbital periods as short as 300 days could be found with a year-long observation**
 - **Possible probe of strong field gravity (if we are lucky enough to find a pulsar close to SgrA*)**
- **Most young pulsars do not have stable timing for longer than a year or so**
 - **Optimum observation duration for pulsar search is 1 year**

Science Case for a GC Observation: G2

passage



- A gas/dust cloud is approaching SgrA* in highly eccentric orbit
 - Pericenter is only 36 light hours (or ~3100 Schwarchild radii)
 - Accretion flow near SgrA* may become dominated by this cloud
 - As the cloud breaks up and fragments feed into the central accretion flow, there may be giant radiation flares
 - Duty cycle of high energy activity may be increased (i.e. more IR/X-ray flares), gamma-ray observations can test models of flare emission
 - Lots of other observatories are pointing towards the galactic center – significant chance for serendipitous discoveries
- GC is close to pericenter now – Fermi observation at GC is most useful ASAP

Gamma-ray Burst Monitor

- **>9.5sr FoV (~ entire unocculted sky)**
- **250 GRB/year (triggered onboard)**
- **8 keV - 40 MeV (broader energy range than BATSE)**
 - **Overlap with LAT energy range (connects LAT observations with “traditional” GRB range)**
 - **Extension to high energies improved sensitivity to short hard bursts**
- **Localization of GRB by GBM**
 - **<15 degrees initially (calculated onboard within 2 s), designed to provide repoint location for LAT afterglow observations**
 - **Refinements with ground analysis within ~15-30 mins of GRB trigger**
- **Onboard GRB trigger**
 - **More flexible trigger algorithm compared with BATSE -> improved sensitivity to very short GRB and to long soft GRB.**
 - **Onboard trigger classifications (solar flare, particle event, GRB etc)**
 - **Provides repoint recommendation to allow high energy afterglow observations with the LAT**
 - **Provide rapid alert to GRB afterglow observers (via GCN)**

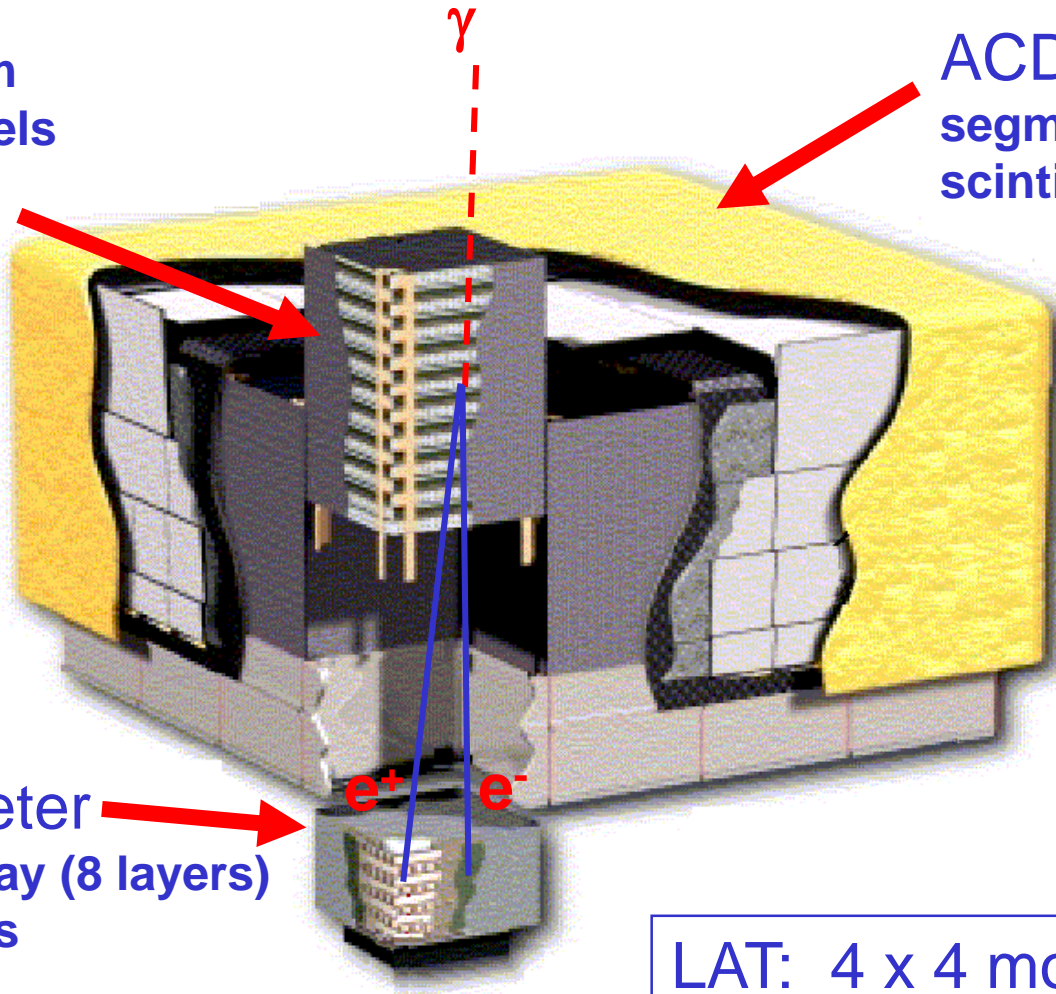
The Large Area Telescope

Si Tracker

pitch = $228\ \mu\text{m}$
 $8.8 \cdot 10^5$ channels
18 planes

ACD

segmented
scintillator tiles

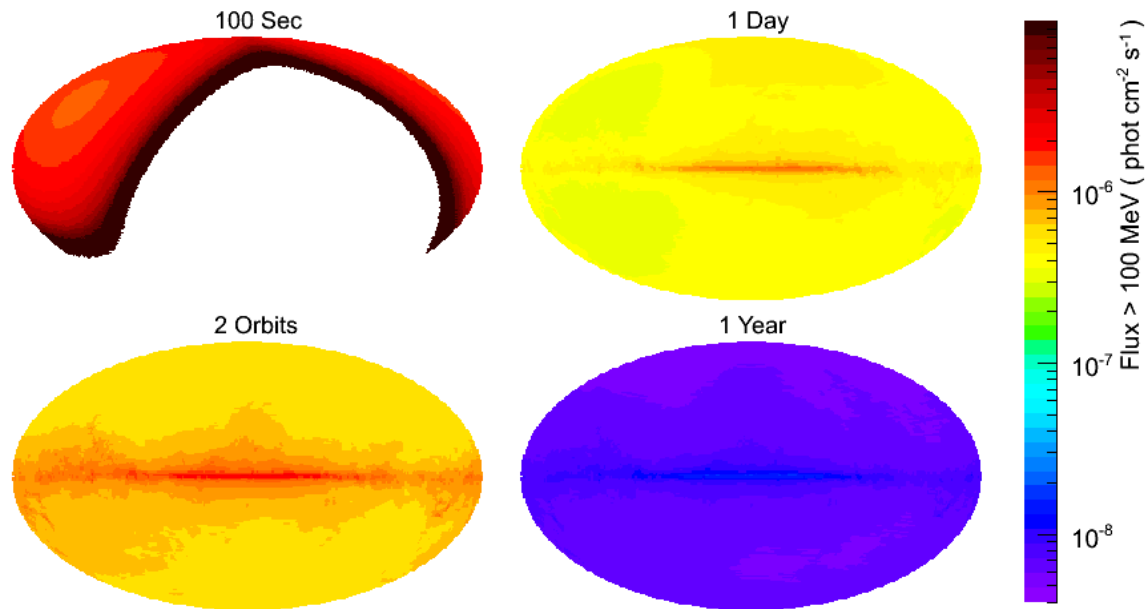


CsI Calorimeter

hadronic array (8 layers)
 $6.1 \cdot 10^3$ channels

LAT: 4×4 modular array
3000 kg, 650 W
20 MeV – 300 GeV

All Sky Coverage

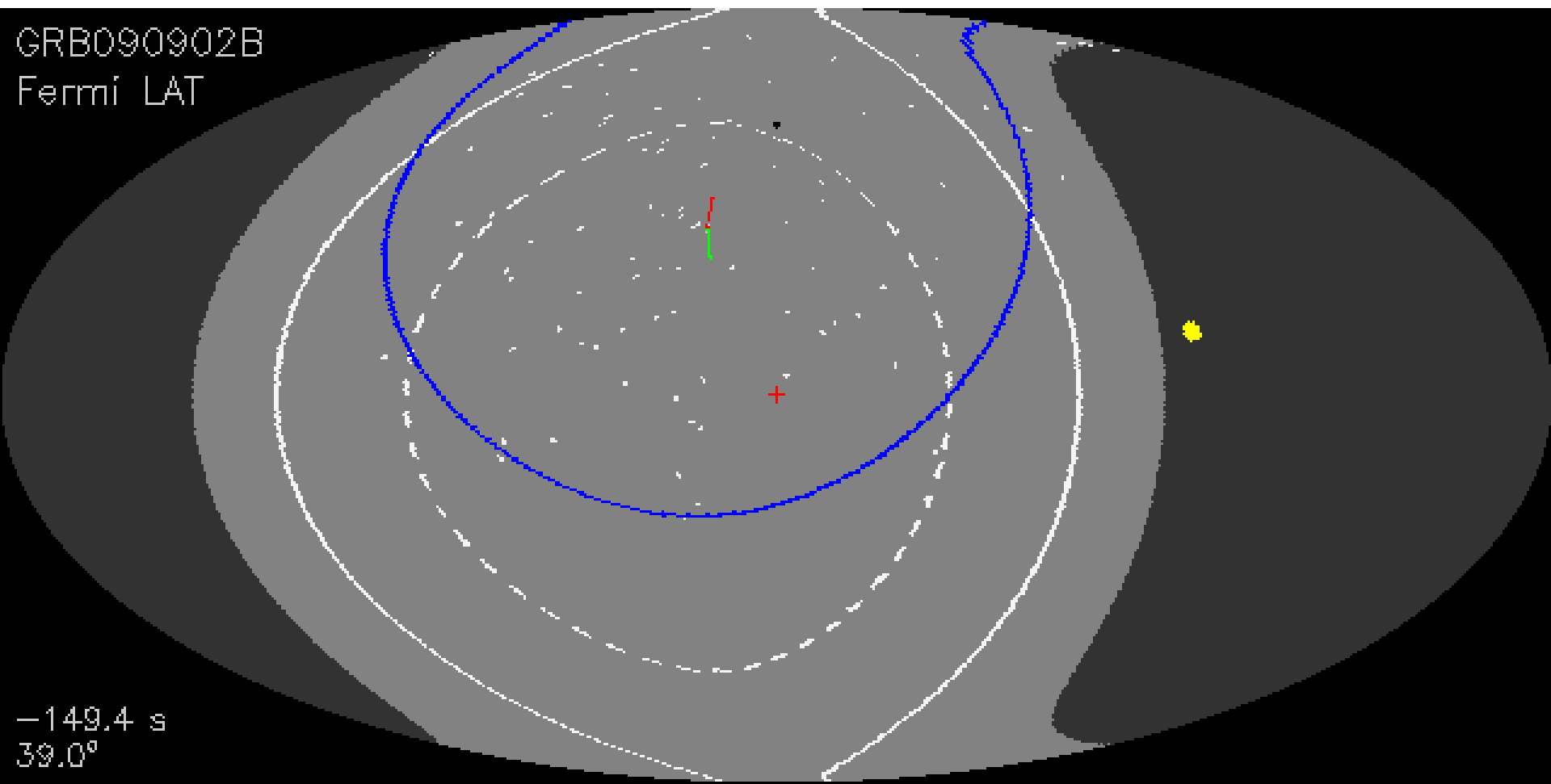


LAT sensitivity on 4 different timescales: 100 s, 1 orbit (96 mins), 1 day and 1 year

- In survey mode, the LAT observes the entire sky every two orbits (~3 hours).
- Multiwavelength/multimessenger observations in coordination with the LAT are limited only by the ability to coordinate to other observations in other wavebands.
- Can also perform pointed observations of particularly interesting regions of the sky.

GRB090902B - Autonomous repoint

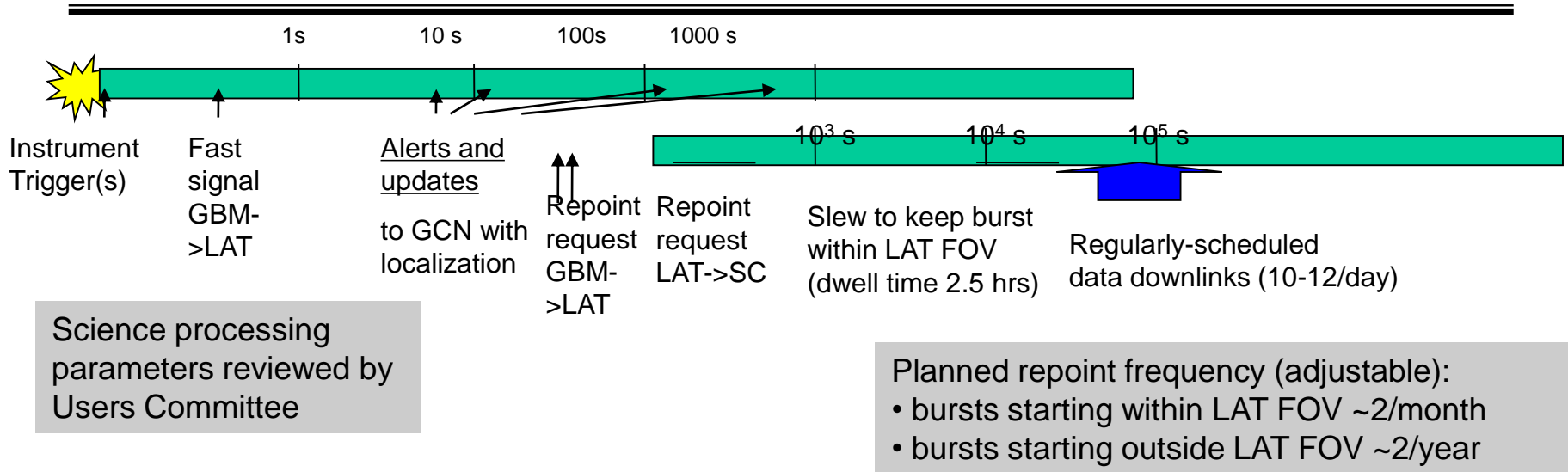
- LAT pointing in celestial coordinates from -120 s to 2000 s
 - Dark region = occulted by Earth ($\lvert z \rvert > 113^\circ$)
 - Blue line = LAT FoV ($\pm 66^\circ$), White points = LAT events



Spacecraft performance

- **Pointing knowledge**
 - **<10 arcseconds, using 2 star trackers (a third is available as a spare)**
- **Absolute Timing**
 - **Better than 300 ns, using GPS and oscillators**
- **Orbit location (knowing where we are)**
 - **~<10m using GPS**
- **Observing modes**
 - **Survey**
 - **view entire sky every 2 orbits, efficient as the Earth does not enter the LAT FoV.**
 - **Inertially pointed**
 - **Scheduled - planned observation at an interesting location**
 - **Autonomous - to automatically put or keep a GRB location within the FoV of the LAT**
 - **Slew requirement of 75 deg in 10 mins, but can reach max slew rates of 0.3 deg/s**

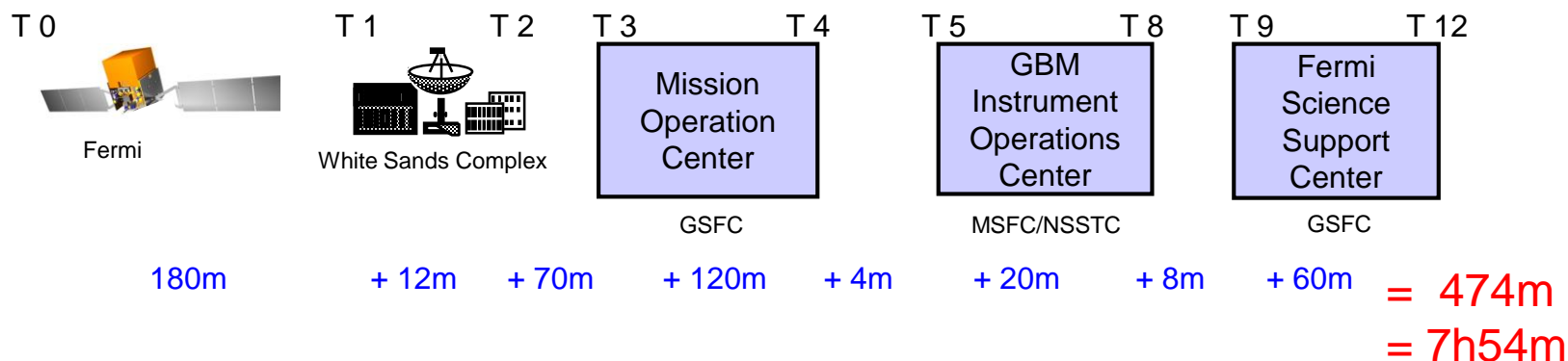
Alerts and Data Flow



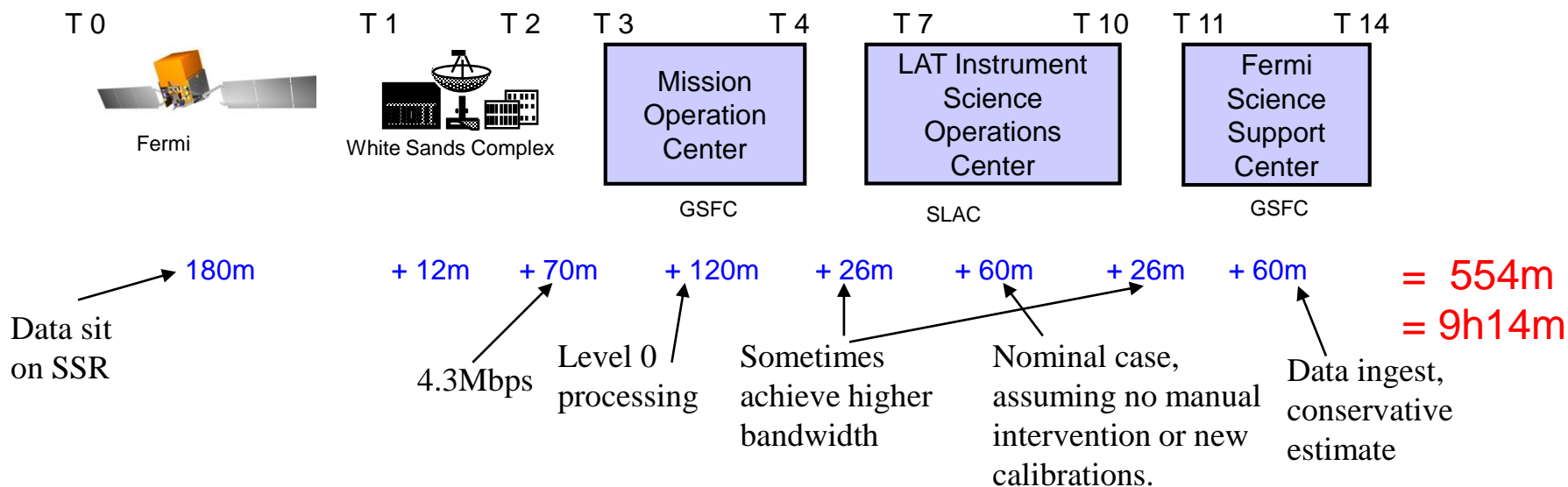
- Onboard processing (both LAT and GBM) - GCN alerts: **location, intensity (cnts), hardness ratio, trigger classification (GRB, solar flare etc)**
- GBM Prompt ground processing (10-30 mins): **updated location, lightcurve**
- LAT ground processing (5-12 hours): **updated location, high energy spectrum, flux (or upper limit), afterglow search results**
- Final ground processing (24-48 hours): **GBM model fit (spectral parameters, flux, fluence), joint LAT-GBM model fit, raw GBM data available. Year 2 and beyond - LAT count data available.**

Data Latency

GBM DATA PATH

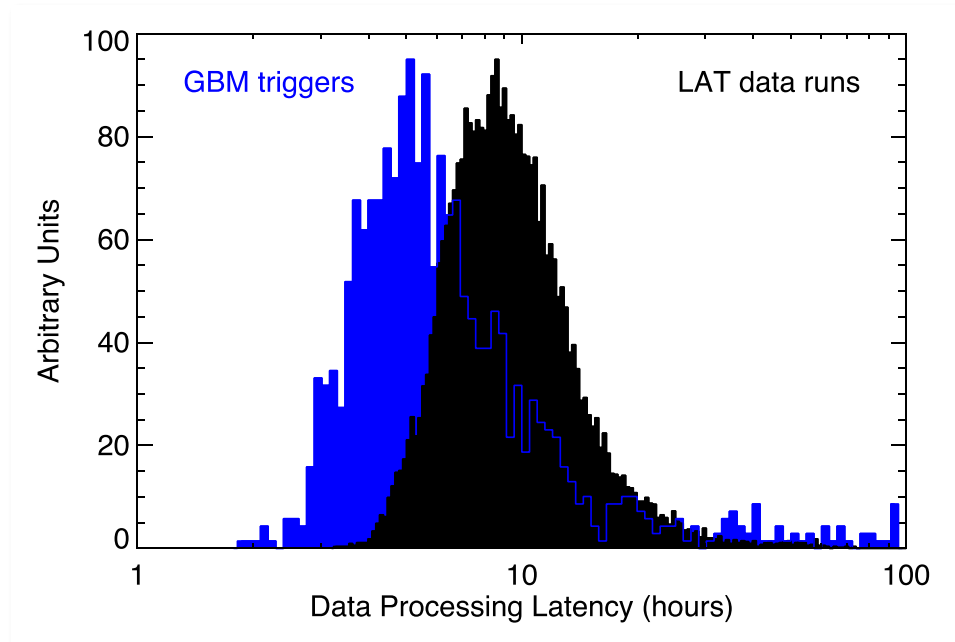


LAT DATA PATH



Data Availability

No proprietary gamma-ray data - Everyone gets access to the data at the same time



Latency requirement is 72 hours, typical latency is much less $\sim < 10$ hours

- All data and software release milestones met at or ahead of schedule
- LAT and GBM instrument teams generate additional high level data (lightcurves, transient alerts, pulsar timing solutions etc) which are served to the community by the FSSC

The Future

- **No consumables, orbit is good until at least 2050**
 - **Mission will likely be able to continue as long as there is funding**
- **No degradation in science performance of instruments**
 - **Improvements in LAT reconstruction and event selections tuned to specific science studies have resulted in improvements in performance since launch**
 - **Operational improvements in GBM (now collecting event-based data), provide enhanced capability**
- **Fermi was proposed as a 10-year mission (5 year requirement, 10 year goal)**
 - **Planned mission continues to at least 2018 (subject to successful senior review)**

Fermi Users Group Members

- Erin Bonning
- Fernando Camilo
- Wei Cui
- Doug Finkbeiner
- Dale Frail (Chair)
- Dieter Hartmann
- Jamie Holder
- Buell Januzzi
- Savvas Kousiappas
- Don Kniffen
- Anna Watts

Plus

- Neil Gehrels
- Ilana Harrus
- Julie McEnery
- Bill Paciesas
- Peter Michelson
- Steve Ritz
- Chris Shrader
- Dave Thompson
- Kathy Turner
- Lynn Cominsky

<http://fermi.gsfc.nasa.gov/ssc/resources/guc/>

The Large Area Telescope

Fermi Science Support Center (FSSC)

- **Supports guest investigator program (Cycle 3 deadline Feb 4)**
- **Provides training workshops**
- **Provides data, software, documentation, workbooks to community**
- **Archives to HEASARC**
- **Joint software development with Instrument Teams, utilizing HEA standards**
- **Located at Goddard**
see <http://fermi.gsfc.nasa.gov/ssc/>
and help desk
<http://fermi.gsfc.nasa.gov/ssc/help/>

Data Releases

- **Beginning of science operations: GBM data + LAT high level data from start of science operations**
- **Feb 6, 2009: LAT bright source list, first LAT analysis software release**
- **Aug 25, 2009: low level LAT data, second LAT analysis software release**

- **~400 queries in first day, many requesting the entire dataset.**
- **Made link to weekly all-sky files more obvious (so number of queries dropped)**

